Effects of LET-dose (Gy) combination on germination and viability rates in durum wheat irradiated by heavy-ion beam

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Durum wheat (*Triticum turgidum* ssp. *durum*) is a tetraploid species with the genome constitution AABB that was derived from two wild diploid ancestral species: the A genome from *T. urartu* and the B genome from *Aegilops speltoides* or another species classified in the Sitopsis section. Therefore, the tetraploid durum wheat genome contains duplicated homoeologous genes, and this characteristic may increase the difficulty of screening for mutants in durum wheat. To avoid this problem, we have chosen to use cultivated diploid einkorn wheat (*T. monococcum*) with the A^m genome, similar to the A genome in bread wheat, for developing a large-scale mutant panel[1], and screened and analyzed several mutants from the mutant panel[2]. However, durum wheat is an important crop species for making pasta, and we have started to make a mutant panel of durum wheat by heavy-ion beam irradiation. First, we examined the effects of the LET-Dose (Gy) combination of ion beam irradiation using Carbon (C) and Argon (Ar) as nuclei on the germination and viability rates in M_1 generation.

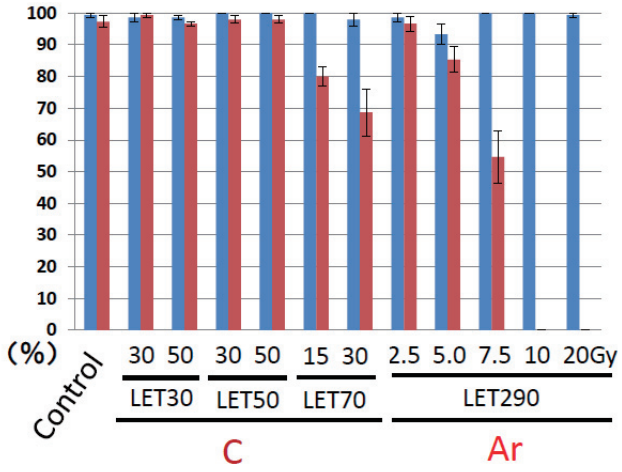

Fig. 1. Effects of heavy-ion beam irradiation on the germination and viability rates in M_1 generation of durum wheat. Percentages (%) of M_1 individuals are shown in each LET-Gy combination of heavy-ion beam irradiation using Carbon (C) and Argon (Ar) as nuclei. Brue and red bars indicate germination and viability rates, respectively.

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Dry seeds of the durum wheat cultivar "Langdon" were irradiated with 15, 30, or 50 Gy and 30, 50, or 70 keV μm^{-1} LET for $^{12}C^{6+}$ ions or 2.5, 5.0, 7.5 10, or 20 Gy of $^{40}Ar^{17+}$ ions (290 keV μm^{-1}) to determine the optimal conditions for mutant generation, using the E5 beam line of Ring Cyclotron (RRC) in the RIKEN RI-beam factory. The germination rate was examined using the irradiated seeds (called M_1 seeds) that were sown in wet-paper-containing petri-dishes. 150 seeds (50 seeds with three replications) were tested for each treatment. The germination rate was not affected by heavy-ion beam irradiation conditions (Fig. 1). Surprisingly, seeds treated with a high dose of the Ar ion beam also showed a normal germination rate.

The M_1 seedlings were planted in the field in October 2014, and the survival ratio (viability rate) was observed in May 2015 at the heading stage with three replications (Fig. 1). The viability rate was reduced to less than 80 % when the LET of the C ion beam was 70 keV μm^{-1}. For the Ar ion beam, the viability rate was reduced to less than 60% with dose greater than 7.5 Gy, and all plants were killed when the dose was 10 and 20 Gy. Based on a previous result of the relationship between viability rate and mutation rate in diploid wheat (K. Murai, unpublished data), the LET-Gy condition with 80% viability is optimal for mutant generation. As a follow up study, therefore, we are now examining the condition with LET50-70Gy for the C ion beam in addition to LET70-15Gy.

Durum wheat cultivars are usually late-heading and not suitable for cultivation in Japan, because of a rainy season from June to July. All known cultivars of durum wheat show pre-harvest sprouting when exposed to prolonged rainfall before harvest. Furthermore durum wheat cultivars are susceptible to Fusarium head blight disease. Because of these disadvantages, durum wheat has not been cultivated in Japan. Recently, one durum wheat cultivar "Setodure" was developed by the National Agriculture and Food Organization. However, "Setodure" is still susceptible to Fusarium head blight, and was therefore released in a limited manner in the Seto-uchi region which receives little rain.

To develop durum wheat cultivars suitable for wide regions in Japan, we are focusing on identifying mutations of early heading, short culm, and resistance against pre-harvest sprouting and Fusarium head blight in durum wheat using heavy-ion beam mutagenesis.

References

1) K. Murai et al., Nucl. Instrum. Meth. Phys. Res. B **314**, 59 (2013).
2) A. Nishiura et al., Breeding Sci. **64**, 213 (2014).